Amended Claims
submitted October 2007

Claims amended: 7,31
New claims added: (none)
Claim cancelled: 32.

Claim 1 (original). A coolant pumping apparatus, wherein:

[2] the apparatus is structured for pumping liquid coolant around the coolant circulation circuit of an engine and associated radiator;

[3] the apparatus includes a fixed housing, having walls which define a pumping-chamber;

[4] the apparatus includes a pump impeller, having blades, and includes a rotary-driver for rotating the impeller;

[5] the pump impeller lies inside the pumping-chamber, and is effective to pump coolant through the chamber;

[6] the apparatus includes a radiator-port, for making coolant-conducting communication between the pump impeller and the radiator;

[7] the apparatus includes a radiator-port-closer;

[8] the radiator-port-closer is mechanically movable in a port-closure mode of movement, being movement between a port-open position with respect to the said radiator-port, and a port-closed position;

[9] the apparatus includes a rad-port-thermal-unit, which includes:

a coolant-temperature sensor;

[10] a fixed-element and a thermally-movable-element, the thermally-movable-element being movable relative to the fixed-element in response to changes in the coolant-temperature sensed by the sensor;

[12] a rad-port-driver, which is so structured as to convert movement of the thermally-movable-element of the rad-port-thermal-unit into corresponding movement of the radiator-port-closer in the port-

closure mode;

[14] the apparatus includes a set of swirl-vanes;

[15] the swirl-vanes are so arranged in relation to the impeller as to impart a rotary swirl motion to the flow of coolant passing through the impeller;

[16] the apparatus includes a vane-mounting-structure, having a vane-orientation-guide;

[17] the swirl-vanes are mechanically movable in a vane-orientation mode of movement, their movement constrained by the vane-orientation-guide, being movement between a flow-reducing orientation of the swirl-vanes relative to the rotary impeller, and a flow-boosting orientation;

[18] the vane-orientation-guide is so structured as to constrain the swirl-vanes of the set all to move in unison with each other;

[19] the apparatus includes a swirl-vane-thermal-unit, which includes:

[20] a coolant-temperature sensor;

[21] a fixed-element and a thermally-movable-element, the thermally-movable-element being movable relative to the fixed-element in response to changes in the temperature sensed by the sensor;

[22] a swirl-vane-driver, which is so structured as to convert movement of the thermally-movable-element of the swirl-vane-thermal-unit into corresponding movement of the swirl-vanes in the vane-orientation mode of movement;

[23] and the set of swirl-vanes, the radiator-port, and the radiator-port-closer, are located inside the pumping-chamber.

Claim 2 (original). Apparatus of claim 1, wherein the set of swirl-vanes, the radiator-port, and the radiator-port-closer, are located inside the pumping-chamber in the following sense:

[2] in the apparatus, the flow of coolant passing through the impeller has a minimum cross-sectional area of min-A sq.mm, the squareroot of which is min-D mm;

[3] the pumping-chamber is the chamber defined by those portions of the walls of the fixed housing that lie within about 2 x min-D millimetres of the

blades of the impeller;

[4] at least a portion of the radiator-port, at least a portion of the radiator-port-closer, and at least a portion of the swirl-vanes, are located inside the pumping-chamber, so defined.

Claim 3 (original). Apparatus of claim 1, wherein:

[2] the thermally-movable-element of the rad-port-thermal-unit and the thermally-movable-element of the swirl-vane-thermal-unit are combined in a structurally-unitary common thermally-movable-element;

[3] the swirl-vane-driver and the rad-port-driver are so structured as to convert movement of the common thermally-movable-element into corresponding movements of both the radiator-port-closer in the port-closure mode, and the swirl-vanes in the vane-orientation mode of movement.

Claim 4 (original). Apparatus of claim 3, wherein the radiator-port-closer is an axial-slide valve.

Claim 5 (original). Apparatus of claim 1, wherein:

[2] the radiator-port-closer and the set of swirl-vanes are combined in a single structural unit termed the combined rad-port-closer/swirl-vanes;

[3] the thermally-movable-element of the rad-port-thermal-unit and the thermally-movable-element of the swirl-vane-thermal-unit are combined in a structurally-unitary common thermally-movable-element;

[4] the rad-port-driver and the swirl-vane-driver are combined in a structurally-unitary common-driver;

[5] the common-driver is so structured as to convert movement of the common thermally-movable-element into corresponding movement of the combined rad-port-closer/swirl-vanes, being movement both in the port-closure mode and in the vane-orientation mode.

Claim 6 (original). Apparatus of claim 1, wherein:

[2] the radiator-port-closer and the set of swirl-vanes are combined in a single structural unit termed the combined rad-port-closer/swirl-vanes;

[3] the rad-port-driver and the swirl-vane-driver are so structured as to convert movement both of the thermally-movable-element of the rad-port-thermal-unit and of the thermally-movable-element of the swirl-vane-thermal-unit into corresponding movement of the combined rad-port-closer/swirl-vanes, being movement both in the port-closure mode and in the vane-orientation mode.

Claim 7 (currently amended). Apparatus of claim 6, wherein:

[2] the apparatus includes a by-pass port, through which coolant can [~~by~~] be circulated through the engine by the impeller;

[3] the swirl-vanes, when closed, close off the radiator-port, but do not close off the by-pass port, whereby coolant can still circulate through the engine even when the radiator-port is completely closed.

Claim 8 (original). Apparatus of claim 1, wherein the swirl-vanes are located immediately upstream of the impeller blades.

Claim 9 (original). Apparatus of claim 1, wherein:

[2] the swirl-vanes are pitched around a pitch-circle, and the pitch-circle is concentric with the axis of the impeller;

[3] the swirl-vane-driver includes a swirl-vane-actuating-ring, which is guided for rotation co-axially with the pitch-circle, and which is driven to rotate by the said movement of the thermally-movable-element of the swirl-vane-thermal-unit;

[4] the arrangement of the apparatus is such that rotation of the swirl-vane-actuating-ring is effective to produce corresponding re-orientation of the swirl-vanes; and

[5] the swirl-vanes occupy at least sixty percent of the circumference of the pitch-circle.

Claim 10 (original). Apparatus of claim 1, wherein the swirl-vanes are arranged to lie in contact against each other to close off the radiator-port.

Claim 11 (original). Apparatus of claim 1, wherein the rotary-driver includes a mechanical connection to the engine, whereby the rotary impeller is driven at a speed proportional to engine speed.

Claim 12 (original). Apparatus of claim 1, wherein the swirl-vane-driver and the rad-port-driver are so structured that:

[2] the radiator-port-closer substantially cannot move, in the port-closure mode, other than in correspondence with movement of the rad-port-driver; and

[3] the swirl-vanes substantially cannot move, in the vane-orientation mode, other than in correspondence with movement of the swirl-vane-driver.

Claim 13 (original). Apparatus of claim 5, wherein:

[2] the common-driver is so structured that movement of the thermal-driver, responsive to an increase in the coolant-temperature from cold to hot, is effective:-

[3] - to move the radiator-port-closer, in the said port-closure mode, away from the radiator-port-closed position towards the radiator-port-open position; and also

[4] - to move the swirl-vane, in the said vane-orientation mode, away from the flow-reducing orientation towards the flow-boosting orientation.

Claim 14 (original). Apparatus of claim 13, wherein:

[2] the common-driver has an overall range of movement, from cold to hot;

[3] the common-driver is so structured that:-

[4] - the movement of the radiator-port-closer, in the port-closure mode, towards the radiator-port-open position, occurs as a radiator-port-closer portion of the overall range of movement of the common-driver; and

[5] - the movement of the swirl-vane, in the vane-orientation mode, towards

the flow-boosting orientation, occurs as a vane-orientation portion of the overall range of movement of the common-driver.

Claim 15 (original). Apparatus of claim 13, wherein the common-driver is so structured that:

[2] the radiator-port-closer portion of the overall range of movement of the common-driver occurs when the temperature of the coolant is towards the cold end of the range;

[3] the vane-orientation portion of the overall range of movement of the common-driver occurs when the temperature of the coolant is towards the hot end of the range.

Claim 16 (original). Apparatus of claim 13, wherein the common-driver is so structured that:

[2] there is no overlap between the radiator-port-closer portion of the overall range of movement of the common-driver and the vane-orientation portion;

[3] in that the radiator-port-closer portion is finished, the radiator-port being then open to full flow of coolant therethrough, substantially before the vane-orientation portion commences.

Claim 17 (original). Apparatus of claim 13, wherein the common-driver is so structured that:

[2] over a unison-portion of the overall range of movement of the common-driver, there is overlap between the radiator-port-closer portion of the overall range of movement of the common-driver, and the vane-orientation portion;

[3] in that, over the unison-portion, the common-driver constrains the swirl-vane and the radiator-port-closer to move together, in unison.

Claim 18 (original). Apparatus of claim 13, wherein the common-driver is so structured that, over a lost-motion portion of the overall range of movement of the common-driver, movement of the common-driver produces

corresponding movement of one of either the radiator-port-closer or the swirl-vane, while the other does not undergo corresponding movement.

Claim 19 (original). Apparatus of claim 18, wherein the common-driver is so structured that:

[2] over a cold-lost-motion portion of the overall range of movement of the common-driver, movement of the common-driver produces corresponding movement of the radiator-port-closer in the port-closure mode, while the swirl-vane does not undergo corresponding movement in the vane-orientation mode;

[3] over a hot-lost-motion portion of the overall range of movement of the common-driver, movement of the common-driver produces corresponding movement of the swirl-vane in the vane-orientation mode, while the radiator-port-closer does not undergo corresponding movement in the port-closure mode.

Claim 20 (original). Apparatus of claim 1, wherein the coolant-temperature-sensor of the rad-port-thermal-unit is physically separate from the coolant-temperature-sensor of the swirl-vane-thermal-unit.

Claim 21 (original). Apparatus of claim 20, wherein the coolant-temperature-sensor of the rad-port-thermal-unit and the coolant-temperature-sensor of the swirl-vane-thermal-unit are so located as to measure coolant temperatures at different locations of the coolant circulation circuit.

Claim 22 (original). Apparatus of claim 3, wherein:

[2] the rad-port-thermal-unit and the swirl-vanes-thermal-unit are combined in a structurally-unitary combined thermal-unit;

[3] the combined thermal-unit comprises a mechanical thermostat, having a temperature-sensitive bulb which expands/contracts in accordance with the temperature of the coolant, and a movable-element of the combined-thermal-unit comprises a movable stem of the thermostat.

Claim 23 (original). Apparatus of claim 22, wherein:

[2] a rate of the thermostat comprises the movement of the stem, in length units, per degree change in temperature of coolant, and:

[3] the thermostat has two different rates, being an initial-opening rate, and a warmed-up rate;

[4] the initial-opening rate is the rate of movement of the stem that obtains upon the coolant reaching a warmed-up temperature, to move the radiator-port closer from the closed to the open position.

Claim 24 (original). Apparatus of claim 23, wherein the warmed-up rate is in two parts, being a cooler part and a hotter part of the warmed-up temperature range, and the rate in the hotter part is greater than the rate in the cooler part.

Claim 25 (original). Apparatus of claim 1, wherein:

[2] the swirl-vanes are situated immediately adjacent to, and upstream of, the impeller; and

[3] the radiator-port is situated upstream of the swirl-vanes.

Claim 26 (original). Apparatus of claim 1, wherein:

[2] the impeller has a set of primary blades and a set of secondary blades;

[3] the impeller is so shaped and configured that coolant emerging from the primary blades has such direction and velocity as to be partially deflected away from the entrances of the secondary blades;

[4] whereby, when the impeller is rotating at slow rotational speeds, a relatively large proportion of the flow emerging from the primary blades enters the secondary blades, but, when the impeller is rotating at high speeds, only a relatively small proportion of the flow emerging from the primary blades enters the secondary blades.

Claim 27 (original). Apparatus of claim 26 wherein the secondary blades are predominantly radial.

Claim 28 (original). Apparatus of claim 26, wherein the flow has to turn around a promontory in order to enter the secondary blades, and the flow is so directed that the faster the flow, the less its inclination to round the promontory and enter the secondary blades.

Claim 29 (original). Apparatus of claim 1, wherein:

[2] the circuit includes a heater, and the walls of the pumping chamber include a heater-port, through which coolant from the heater can pass through the pumping chamber;

[3] the apparatus includes a heater-port-closer, which is effective to close the heater-port in accordance responsively to the temperature of the coolant.

Claim 30 (original). Apparatus of claim 2, wherein the set of swirl-vanes, the radiator-port, and the radiator-port-closer, are located substantially wholly inside the pumping-chamber, so defined.

Claim 31 (currently amended). A coolant pumping apparatus, wherein:

[2] the apparatus is structured for pumping liquid coolant around the coolant circulation circuit of an engine and associated radiator;

[3] the apparatus includes a fixed housing, having walls which define a pumping-chamber;

[4] the apparatus includes a pump impeller, having blades, and includes a rotary-driver for rotating the impeller;

[5] the rotary-driver includes a mechanical connection to the engine, whereby the rotary impeller is driven at a speed proportional to engine speed;

[6] the impeller has a set of primary blades and a set of secondary blades;

[7] <u>the impeller, containing the two sets of blades, is physically unitary, whereby the two sets of blades are constrained to rotate only in unison;</u>

[8] the impeller is so shaped and configured that coolant emerging from the primary blades has such direction and velocity as to be partially deflected away from the entrances of the secondary blades;

[9] whereby, when the impeller is rotating at slow rotational speeds, a relatively

large proportion of the flow emerging from the primary blades enters the secondary blades, but, when the impeller is rotating at high speeds, only a relatively small proportion of the flow emerging from the primary blades enters the secondary blades;

[10] the secondary blades are predominantly radial;

[11] the structure of the apparatus is such that the flow has to turn around a promontory in order to enter the secondary blades, and the flow is so directed that the faster the flow, the less its inclination to round the promontory and enter the secondary blades.

Claim 32 (cancelled).